IMPACT ANALYSIS OF THE MASSACHUSETTS 1998 RESIDENTIAL ENERGY CODE REVISIONS

Prepared for

Massachusetts Board of Building Regulations and Standards
Boston, Massachusetts

Prepared by

XENERGY Inc.
Portland, Oregon

May 14, 2001

S

EXECUTIVE SUMMARY

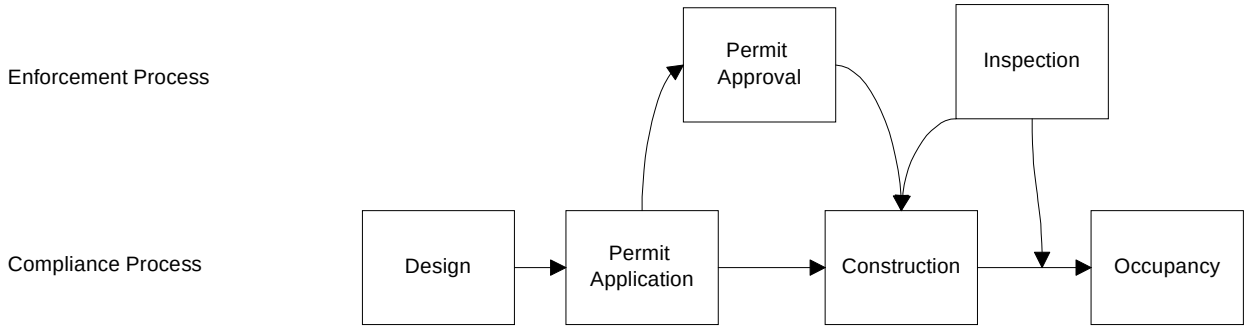
On March 1, 1998, a new residential energy conservation code went into effect in Massachusetts.[1] This report presents the results of a study of compliance with this code and its impacts. The study has been conducted for the Massachusetts Board of Building Regulations and Standards (BBRS) by a team of consultants led by XENERGY, Inc.[2]

Although the new code provisions afford builders and architects greater design flexibility, they entail potentially greater complexity. Thus, the code revisions have the potential for yielding greater energy savings, but if there is inadequate compliance or enforcement, the benefits of the new code will be diminished. This study addresses the overall effects of the new code, taking into account the degree of code compliance, energy and air emission savings attributable to the new code, and the attitude of builders, code officials, and others toward the new code.

S.1 APPROACH

To provide context for this study, it is useful to identify the steps in the process through which an energy code affects the performance of a new building. Figure S-1 shows the key steps from

Figure S-1
The Building and Compliance Process



building design through occupancy. The figure shows two paths—one is the **compliance process** through which the building industry achieves compliance with the code and the other is the **enforcement process** through which building officials enforce the code to ensure compliance.

[1] *780 CMR Appendix J. Energy Conservation Code for New Construction Low-Rise Residential Buildings.*

[2] Other team members included Peregrine Energy Group and RISE Engineering.

During the design process, the designer needs to prepare a design that complies with the code. The design information is incorporated in the permit application. The code official is responsible for ensuring that the proposed design meets the code requirements and construction can then proceed. During construction, the builder and subcontractors need to incorporate the features identified in the permit application that are required for compliance. To ensure this happens, code officials conduct inspections with a final inspection usually occurring after construction is completed. The buyer then takes possession of the house and occupies it.

The effects of the 1998 code revisions depended on the actions that occurred at each step in the process shown in Figure S-1. Ultimately, performing to the requirements established by the code required builders to build houses that met the code and building officials to conduct the necessary inspections and enforce the code requirements. In this study, we used both onsite building data collection and building market player interviews to assess how successful compliance and enforcement have been.

To evaluate the impacts of these code revisions, we completed the following data collection steps and analyses:

- Conduct builder interviews and review existing studies to compile residential baseline (pre-code revisions) construction characteristics
- Identify a representative sample of new houses
- Compile building data for each house from the local building official's office
- Conduct onsite surveys of each house (186 surveys were completed) and document actual construction characteristics
- Select a sample of residential market actors and conduct in-depth interviews on their code perceptions, awareness, knowledge, and attitudes
- Analyze code compliance of each surveyed house based on thermal performance requirements, specific construction requirements, and equipment sizing
- Identify factors responsible for noncompliance
- Investigate relationships between compliance and market and housing factors
- Estimate energy savings and emissions impacts of the code revisions relative to the baseline construction practices.

S.2 MAJOR FINDINGS AND CONCLUSIONS

Major findings and conclusions are presented in four areas—observations about the code and implementation process, compliance rates and factors related to compliance, causes of noncompliance, and code energy and emissions impacts.

S.2.1 Observations about the Code and Implementation Process

Based on feedback from market actors, the BBRS has done a good job of informing residential construction professionals about the features of the code regarding the design, permit application, and construction requirements for new residences. Code awareness and understanding appeared

to be quite good two years after the code changes had gone into effect. All market actor groups indicated, however, that they could use more information on energy efficiency, particularly on new products and techniques. Most indicated that they looked to the BBRS and its trainings, professional organizations, and other professionals for information.

The acceptance level of the revised code was generally quite high. Many market actors noted that the code requirements had increased the overall quality of houses being built, and particularly cited the NFRC certification requirement for windows as a significant upgrade.

The use of MAS*check* was the most common method to demonstrate compliance at the permit stage. All the local building code officials we interviewed used MAS*check* reports to verify compliance and market players accepted the need to use MAS*check*. Most players were supportive of MAS*check* and its flexibility, but relatively few made use of that flexibility. Several designers noted that the MAS*check* Windows™ operating system format was not compatible with their MacIntosh™ and CAD design systems.

Although MAS*check* was widely accepted, only a few communities crosschecked building specifications on the MAS*check* printout against the building plans or performed any site checking between MAS*check* and what was actually constructed; our onsite surveys confirmed that large discrepancies often existed between the data in the filed MAS*check* output and the characteristics of the building as-built. This suggested a potential downside to the use of MAS*check*—some code officials may have begun to rely on the initial MAS*check* filing as an adequate verification of code compliance and not followed through adequately during construction and post-construction inspections to verify compliance of the constructed building.

Other major observations on the code and compliance process were the following:

- Building industry members and code officials suggested there was a need for a more checklist-oriented approach for energy-efficiency requirements, especially as a means to organize the inspection process.
- Market actor interviews and onsite surveys indicated that code official inspections of insulation, penetration sealing, and duct sealing requirements were often insufficient, and varied considerably by geographic area.
- Filings with building departments were insufficient in almost a third of the cases to determine how energy code compliance was determined.
- Although some builders were interested in prescriptive approaches, only 2% of the houses used the prescriptive package compliance approach.
- Energy-code enforcement varied significantly among communities, although the variation was not substantially different from other parts of the code.

S.2.2 Compliance Rates and Factors Related to Compliance

We found that only 46.4% of the houses complied with the overall thermal performance (UA) requirements of the code. Although less than half the houses complied strictly with the code

thermal performance requirements, only 20% exceeded the compliance threshold by more than 10%.

Specific compliance findings included the following:

- As-built characteristics often differed markedly from the characteristics in the permit documents—areas and perimeters varied significantly in nearly 80% of the cases and insulation levels differed substantially in about one-third of the cases.
- More than 80% of the houses did not meet penetration or duct system sealing requirements.[3] Our duct system tests showed that the average losses to outside the house envelope were about 22%, or about twice what good sealing practices can achieve.
- Air infiltration data, however, showed that most house envelopes were sealed well enough to achieve relatively low infiltration rates.
- The average heating system was oversized by 35% over what the code allowed. On the other hand, cooling systems typically met the sizing requirements.
- Houses heated with natural gas or propane were much more likely to comply with the code than those heated with oil (only a little over a third of these houses complied with the code). Houses with furnaces were twice as likely as those with boilers to meet the code. Both these results were related to the fairly common use of high efficiency (>90% AFUE) gas furnaces.
- Compliance rates were considerably lower in the coldest areas of the state—only about one-third of the new houses met the code requirements in the coldest areas.
- There was some evidence that the compliance rates were lower in the areas where code officials had to inspect and approve more houses, but the differences were not statistically significant.
- Based on self-reported thermostat setpoints, only a small proportion of occupants regularly set back their thermostats during the night and unoccupied periods.

S.2.3 Causes of Noncompliance

Because this code was performance-based, it was not possible to pinpoint specific areas of noncompliance. However, comparing the characteristics of complying and noncomplying houses revealed which features contributed to noncompliance. Based on this analysis, we drew the following conclusions:

- Noncomplying houses typically had less insulation in wall cavities.
- Noncomplying houses usually had less insulation in floor cavities. The average R-value in noncomplying houses was about R-2 less than in complying houses.
- Noncomplying houses were very unlikely to have continuous insulation in the envelope components.
- Noncomplying houses, on the average, had heating equipment that was about three percentage points less efficient than the equipment in complying houses.

[3] We took a strict "all or nothing" approach in assessing compliance with the sealing requirements.

- Poor duct sealing practices contributed to noncompliance.

S.2.4 Energy and Emissions Impacts of the Code

The energy code provided direct energy savings for occupants and emissions reductions that benefited society at large. Table S-1 summarizes the estimated annual space heating and cooling (central air conditioning only) energy savings resulting from the code. Average air conditioning savings were about 6% and space heating savings were about 23% of the baseline levels.[4]

Table S-1
Annual Energy Savings per House

	Space Cooling Electricity, kWh	Space Heating, All Fossil Fuels, Therms
Complying Houses with Equipment	196	302
Noncomplying Houses with Equipment	136	231
% Population with Equipment	58.1%	100%
Average over All Houses	97.9	264
Average % Savings Relative to Baseline	5.9%	23.4%

The table shows that, on the average, energy savings occurred for both houses that complied and did not comply with the code. However, the space heating and cooling energy savings for complying houses were about 50% larger than they were for noncomplying houses.

Reduced use of fossil fuels for heating and electricity for cooling produced emissions reductions. Table -S-2 summarizes the annual reduction in emissions estimated for all new houses constructed under the revised code in 2000.

Table -S-2
Average Annual Emissions Savings

	SO_x	NO_x	CO_2
Total Savings for New Houses	30.4 ton/yr	24.5 ton/yr	26,600 ton/yr
Note: Estimate of new houses is based on U.S. Census data for housing units authorized (14,442) in 2000.			

[4] We note that these estimates were based on a simulation model and, since data were not available on actual consumption, the results may overstate or understate the actual impacts.

S.3 RECOMMENDATIONS

Based on the study findings and conclusions, we developed recommendations in four areas. These are presented below.

- Specific types of training and information dissemination should be implemented to increase code awareness, understanding, and compliance

  ⇒ The BBRS should institute additional training in the areas and on the topics identified below.
  ⇒ Other types of information dissemination should be implemented and targeted at the topics and market actors that will be most influenced to increase code compliance. The BBRS should work with respected professional organizations to train their members and help disseminate information.
  ⇒ Refresher training should be offered for code officials and others who have already been trained.
  ⇒ Training should be offered for code officials who missed the first round of training. Training should be implemented to improve consistency in how the code is enforced across jurisdictions.

- Specific messages, information, and materials should be developed and disseminated

  ⇒ Market actors should be made aware of what the impacts are of not meeting the code and how often new houses fail to meet it.
  ⇒ Information on good or exemplary practices and improved energy-efficiency technologies should be compiled and made available to builders and their contractors. Code officials also should be informed of these practices and technologies so that they can expedite acceptance of them under the code and communicate to other code officials and builders about their suitability.
  ⇒ Market actors should be informed about areas in which compliance has been poor, such as sealing of ducts, heating equipment oversizing, and sealing of penetrations.
  ⇒ Tools should be developed to simplify compliance and enforcement. Two examples are standardized checklists to verify compliance and heating/cooling system efficiency and sizing checklists or sheets.
  ⇒ The code language regarding sizing of combined space and water heating equipment should be clarified.
  ⇒ Information on the benefits of thermostat setback/setup during appropriate times should be compiled and disseminated through channels that will reach homeowners.
  ⇒ The development of a MacIntosh™-compatible version of MAS*check* should be explored.
  ⇒ The feasibility of providing annual updates of the building code through the State Bookstore on searchable CD-ROMs should be assessed.

- Information dissemination and training should be targeted

  ⇒ Builders should be specially targeted for training and information dissemination. Designers and suppliers could be used as information channels to reach builders.
  ⇒ Information and training on proper sizing of heating and cooling equipment should be targeted to contractors that install these systems. Equipment distributors might serve as an effective channel for educating these contractors.
  ⇒ Code officials also should be targeted to inform them about how often new houses fail to meet the code and the impacts of noncompliance on homebuyers.
  ⇒ Information should be targeted to homebuyers on the benefits of meeting the code, things to look for to ensure a new house complies, and good operating practices.
  ⇒ Special efforts should be directed at increasing compliance of houses with oil heat and at improving compliance in the coldest parts of the state.

- Specific practices and procedures should be improved

  ⇒ Code officials should verify construction practices against the original compliance documentation, or require that compliance of houses as-built be verified.
  ⇒ All building departments should establish practices to ensure that all materials are present for each house. Manufacturers' cut sheets on windows, doors, and heating/cooling equipment should be included in the files to facilitate compliance verification.
  ⇒ Builders and their contractors should increase their use of foam sealants to reduce infiltration, apply mastic to seal ducts, and size heating equipment appropriately.
  ⇒ Special attention should be directed to increasing the use of a more whole-building approach to the design, construction, and compliance process. In general, approaches are needed for improving communications between the builder (prime contractor) and the subcontractors and suppliers so that new houses are treated more as integrated systems.
  ⇒ Builders should increase their use of higher insulation levels in floors and walls and use continuous insulation where appropriate to comply with the code.
  ⇒ The market for prescriptive approaches to compliance should be investigated further.